THE UNIVERSITY OF ALBERTA

THE EFFECTS OF SELECTED TRAINING PROGRAMS ON SHOULDER FLEXIBILITY

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled The Effects of Selected Training Programs on Shoulder Flexibility submitted by Glen L. Bergeron in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

The purpose of the research was to evaluate and compare flexibility changes as a result of Static Stretching, Nautilus Weight Training, Nautilus supplemented by static stretching and a control group.

Twenty-eight male volunteers underwent five measures of shoulder flexibility prior to and immediately following a four week training program. The subjects were randomly assigned to four treatment groups; (1) Static Stretching Exercises, (2) Nautilus Weight Training, (3) Nautilus Weight Training supplemented with Static Stretching Exercises and (4) a control group.

The data was analyzed using a One-Way Analysis of variance and Newman Keuls Multiple Comparison Test. Within the confines of the study, the null hypothesis was rejected at the .05 level of confidence for all but one measure of shoulder flexibility (shoulder extension). A comparison of the three treatment groups showed that the Static Stretching group was responsible for statistically significant changes in two of the five flexibility measures, the results from the data showed statistically significant changes in two of the five measures using the Nautilus Training Program and the Nautilus Training Program supplemented by Static Stretching Exercises proved to develop statistically significant increases in four of the five flexibility measures. It was concluded that for best results in flexibility development, the Nautilus Weight Training Program should be supplemented by Static Stretching Exercises and that Nautilus Weight Training alone is better that Static Stretching Exercises alone.

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TABLE OF CONTENTS

CHAPTER		PAGE
I	INTRODUCTION	1
	The Problem	2
	Hypothesis	3
	Delimitations	3
	Definition of Terms	4
II	REVIEW OF RELATED LITERATURE	5
	What is Flexibility?	5
	Why Do We Need Flexibility	7
	Flexibility Exercises	8
	Measuring Flexibility	9
	Strength Training and Flexibility	12
	Flexibility and Nautilus Weight Training	13
III	METHODS AND PROCEDURES	15
	Apparatus	15
	Subjects	18
	Experimental Design	19
	Testing Procedure	19
	Shoulder Flexion	19
	Shoulder Extension	20
	Shoulder Abduction	20

TABLE OF CONTENTS (Cont'd)

CHAPTER		PAGE
	Internal Rotation	20
	External Rotation	21
	Training Procedure	22
	Static Stretching Exercises	22
	Nautilus Training Program	23
	Nautilus and Static Stretching Program	23
	Control Group	24
	Data Analysis	24
IV	RESULTS	25
	Shoulder Flexion	26
	Shoulder Extension	26
	Shoulder Abduction	29
	Internal Rotation	29
	External Rotation	33
V	DISCUSSION	36
	Shoulder Flexion	36
	Shoulder Extension	37
	Shoulder Abduction	37
	Internal Rotation	38
	External Rotation	38
	General Discussion	39
VI	SUMMARY AND CONCLUSIONS	42
	Conclusions	43

TABLE OF CONTENTS (Cont'd)

CHAPTER		PAGE
BIBLIOGRAPHY		44
APPENDIX A.	APPARATUS	48
APPENDIX B.	DATA	55
APPENDIX C.	SUBJECT INSTRUCTIONS	67

LIST OF TABLES

Table	Description	Page
I	Mean Shoulder Flexion, Pre and Post Test, for Each Treatment Group	27
II	Analysis of Variance for Shoulder Flexion Following the Treatment Program	27
III	Newman-Keuls Multiple Comparison Test for Shoulder Flexion following the Treatment Program	28
IV	Mean Shoulder Extension, Pre and Post Test, for Each Treatment Group	28
V	Analysis of Variance for Shoulder Extension Following the Treatment Program	29
VI	Mean Shoulder Abduction, Pre and Post Test for Each Treatment Group	30
VII	Analysis of Variance for Shoulder Abduction Following the Treatment Program	31
VIII	Newman-Keuls Multiple Comparison Test for Shoulder Abduction following the Treatment Program	31
IX	Mean Internal Rotation, Pre and Post Test for Each Treatment Group	32
X	Analysis of Variance for Internal Rotation Following the Treatment Group	32
XI	Newman-Keuls Multiple Comparison Test for Internal Rotation following the Treatment Program	33
XII	Mean External Rotation, Pre and Post Test for Each Treatment Group	34
XIII	Analysis of Variance for External Rotation Following the Treatment Program	34
XIV	Newman-Keuls Multiple Comparison Test for External Rotation following the Treatment Program	35
XV	Statistically Significant Flexibility Measures Attributed to Each Treatment Group	40

LIST OF FIGURES

Figure		Page
1.	O.B. Myrin Goniometer	17

CHAPTER I

INTRODUCTION

Traditionally, the physical education and rehabilitation field has approached the concept of physical fitness from a narrow viewpoint. For many years muscle strength was considered the major criterion when assessing physical fitness. With the advent of Dr. Cooper's concept of aerobic conditioning came an emphasis on cardiovascular endurance as the true indicator of physical fitness. Other programs such as yoga and calisthetics are also guilty of emphasizing one component of fitness and eluding to or even disregarding all other facets of total physical fitness.

The development of fitness equipment has also followed the trend in which a single fitness component is identified and developed at the expense of other components. This trend is readily observable in the design of weight training equipment. Most of the weight training equipment is designed solely for the development of muscle strength. Other fitness components such as cardiovascular endurance and flexibility are ignored.

From a physical conditioning or rehabilitation viewpoint, a fitness program must incorporate all of the components of physical fitness. Until recently, such a program required various types of equipment, supplemental programs and a considerable time investment. Nautilus Sports Medical Industries has introduced a new concept in strength training with their adapted resistance training equipment. Adapted resistance means that the

resistance changes to accommodate for the biomechanical variability of the body's lever system. Using this technique, the manufacturer claims the muscle is maximally loaded throughout its full range of motion. Of equal importance is the fact these machines also incorporate a second fitness component - flexibility.

Darden (1974) considers flexibility and strength to be the two most important factors for the prevention of athletic injuries. Nautilus equipment makes use of a "Pre - stretch" position in an attempt to increase flexibility and range of motion. It also serves to offer resistance to the full length of the muscle. Pre - stretch occurs at the beginning of the exercise because the weight does not return to its original resting position. A continuous stretch is applied to the muscle in an attempt to encourage adaptation and elongation, and improve flexibility.

Until now, flexibility development depended on various manual stretching techniques, be they ballistic or static. If Nautilus training equipment can effectively increase the flexibility component while at the same time increasing muscle strength, there may be some advantage to such a program instead of using a supplemental flexibility program.

The Problem

The problem examined in the study was whether or not physical educators and therapists could rely on the Nautilus training program to effectively develop shoulder flexibility.

The purpose of this study was to evaluate and compare the flexibility increases of the shoulder occurring as a result of a Nautilus training program and a specific series of static stretching exercises. Such a study

would determine whether or not the Nautilus training program for the shoulders required supplementary flexibility exercises.

Hypothesis

The following null hypothesis was investigated:

There is no significant difference between no flexibility training, static stretching exercises, Nautilus training, and Nautilus training supplemented by static stretching exercises.

Delimitations

Twenty - eight males volunteered to act as subjects. Each subject was tested prior to and immediately following the training program which called for three sessions per week (Monday, Wednesday, Friday) for a four week period. The test consisted of five flexibility measures about the shoulder including: forward flexion, extension, abduction, internal and external rotation. Flexibility training was limited to static stretching exercises. Only those Nautilus machines aimed at developing the upper body and the shoulder complex in specific were used during the training program, they include:

1. Combination Pull Over/Torso Machine
2. Double Chest Machine
3. Combination Behind Neck/Torso Arm Machine
4. Double Shoulder Machine
5. Omni Bicep Machine
6. Omni Tricep Machine.

All of the exercises performed on the Nautilus training equipment

that were concerned with upper body development were used during the training program. The reasons for using all upper body exercises was to examine the flexibility increases of the shoulder when flexibility exercises are incorporated with a strength program. To examine one or two components of the program would not have provided a true indication of the program as a whole.

Definition of Terms

For the purpose of this study, ballistic stretching was defined as a flexibility exercise using quick, bouncing movements throughout the full range of movement. Ballistic stretching is also referred to as spring stretch, fast stretch and rebounding stretch. Static stretching was defined as a flexibility exercise utilizing slow rhythmic motion to the point of maximum muscle extension, at which point, the position is held for a period of ten seconds.

CHAPTER II

REVIEW OF RELATED LITERATURE

What is Flexibility

A theoretical definition of flexibility is difficult to define because of the intervening variables that can either enhance or limit flexibility. Generally, flexibility has been defined as the range of movement about a joint. Whenever flexibility is evaluated, the influencing factors must be considered. Wright (1960) looked at the internal resistance of wrist flexion and extension of the cat (said to be similar to that of man) and found that the muscle and its fascial sheaths offered the greatest resistance to free movement. Wessel (1961) stated that flexibility can be limited by tendon shortening and shortening of the muscle fascia. Jensen (1972) identified four influencing factors: (1) bone structure; (2) muscle bulk; (3) extensibility of connective tissue, and (4) fat with respect to obesity and joint movement. According to de Vries (1975), the influence of muscle on flexibility also included the fascial sheaths surrounding the muscle. He also included the skin as a limiting factor although its influence was not of major concern to the healthy individual.

Range of movement, therefore, is that movement about a joint within

the controlled limits of the bone structure, muscle and its fascial sheaths, the connective tissue surrounding the joint and to some extent the skin.

Optimal flexibility is, as yet, undetermined. Cureton (1941) has provided flexibility norms for his functional flexibility tests, but it is difficult to imply that average flexibility is sufficient for athletic success or that too much flexibility will predispose the athlete to injury. Average flexibility, as vague as the term may be, is generally accepted to be sufficient for most sports and that greater flexibility is required for activities such as gymnastics and dance.

Flexibility has also been defined as static and dynamic flexibility. Static flexibility has been described as the range of joint movement within the confining parameters previously described. Dynamic flexibility as described by Wessel (1961) and Walker (1961), is highly related to the speed of movement of a limb. Dynamic flexibility is primarily concerned with the resistance offered by the antagonistic muscle against the agonistic muscle preventing the smooth joint action. Given that the agonistic muscle and fascial sheaths are very inflexible and thus resist being stretched, the speed of movement would be less than if the agonistic resistance were minimal or non-existent.

Our definition of flexibility must, therefore be, the joint movement, be it static or dynamic, permitted within certain limiting confines which include (1) bone structure, (2) muscle bulk, (3) antagonistic resistance of muscle and fascial sheaths, (4) connective tissue, (5) fat and (6) skin.

Why Do We Need Flexibility

There have been innumerable claims as to the contributions of flexibility to the overall physical fitness and athletic performance of the individual. Unfortunately many of these claims are not followed by convincing statistical evidence. In almost any text dealing with flexibility, one can find statements similar to that stated by Klafs and Arnheim (1977).

> "The athlete who gains improved flexibility and increased range of joint movement is able to use his body more effectively and efficiently and is better able to avoid a potential injury provoking situation."

Because of the limited research, it is difficult to conclude whether or not flexibility is a benefit to athletic performance is injury prevention.

Despite the lack of evidence, flexibility has received general acceptance by the large majority of physical educators and therapists. Some advantages of flexibility that have been researched or have come to be accepted include (1) preventing shin splints and muscle soreness through a sustained stretch of the involved muscle before and after activity (de Vries, 1961; Wessel, 1961; Klein, 1967; de Vries,1975); (2) injury prevention, (Cureton, 1941; Jensen, 1972); (3) prevent or relieve orthopedic conditions such as low back pain and general aches and pains (Kraus, 1956; Wessel, 1961; de Vries, 1975); (4) efficient movements as a result of minimum resistance from antagonistic muscles (antagonistic inhibition) allowing fluid and coordinated movement (Cureton, 1941; Fieldman, 1966; Karpovich, 1971; Klein, 1971; Jensen, 1972; de Vries, 1975);

and (5) increased muscular work due to strength increases and output over the full length of the muscle (Darden, 1974; de Vries, 1975).

Flexibility Exercises

Flexibility exercises include: those done quickly in bouncing fashion or ballistically; those done slow and rhythmically or statically; and those using isometric contraction of the agonist followed by concentric contraction of the antagonist referred to as IA-CA (Holt, 1970).

Studies investigating the comparative increases of the three methods described above agree that flexibility increases between ballistic and static flexibility exercises do not significantly differ (Logan, 1961; de Vries, 1962; Cotten,1970; Holt,1970.). Despite any significant advantage, researchers advocate the static exercises (de Vries, 1961; Logan, 1961; de Vries, 1962; Huddlestone, 1964; Cotten, 1970; Karpovich, 1971; Klein, 1971; Jensen, 1972). Reasons for this preference seem to revolve around two major points. The first being less danger of muscle strain during the exercises, using a slow stretch rather than a violent ballistic stretch (de Vries, 1961; Walker, 1961). Secondly, from a physiological viewpoint researchers also refer to the stretch reflex of the muscle. This stretch reflex is an inherent protective mechanism within the muscle to prevent overstressing the muscle. Annulo-spiral endings, flower spray endings and golgi tendon bodies all react to a muscle stretch by initiating a reflexive muscle contraction (de Vries, 1975). Studies have shown that ballistic stretching exercises trigger this myotatic stretch reflex

resulting in muscle contractures instead of elongation. Slow static stretch avoids the stretch reflex and triggers an inverse myotatic stretch reflex allowing the muscle to relax and extend (Huddlestone, 1964; Karpovich, 1971; de Vries,1975).Walker (1961) has demonstrated that the tension incurred during a ballistic stretch is twice that of a static stretch which suggests a greater potential for injury using a ballistic stretching exercise. Walker also found that during the actual static stretch the muscle tension reaches a peak and then remains stable indicating a stress relaxation of the muscle. On the other hand about 50 percent of the tension is lost after ballistic stretch indicating a decreased adaptation to the muscle stretch. Other reasons brought forward in preference of static stretching include (1) an opportunity to consciously relax the muscles (Jensen, 1972), (2) it requires less energy expenditure (de Vries, 1962), and (3) it does not cause muscle soreness (Logan, 1961; de Vries, 1962). in fact, it may relieve muscle soreness (de Vries, 1961).

Holt (1970) conducted a comparative analysis of ballistic, static stretching and IA-CA. He found that the flexibility increases from static and ballistic exercises were equal but that the increases from IA-CA were dramatically greater (6/8 inch to 2.1 inches). Unfortunately, there were no further studies available using IA-CA and because the Nautilus training machines do not use the IA-CA method, the study will concern itself with static stretching exercises.

Measuring Flexibility

Previous studies examining the specificity of flexibility all agree

that there is no measure of general flexibility. Researchers are convinced that flexibility is not an overall trait but rather a specific characteristic describing a specific joint and the muscles that surround that joint (Cureton, 1941; Hupprich, 1950; Dickinson, 1968; Holland, 1968; Harris, 1969; Jensen, 1972; de Vries, 1972). Dickinson (1968) goes one step further saying that flexibility is even specific to each movement of any particular joint. Gaining an understanding of the individual's flexibility fitness requires measurement of each joint. Generalization can not be made from one joint to another.

Techniques for measuring flexibility include such procedures as manual goniometry, goniometric apparatus such as the Leighton flexometer and the Myrin goniometer, or by various indirect methods such as the sit and reach. The manual goniometer is seldom used in research because of the difficulty in standardizing the measurement procedure for repeated tests. A goniometric apparatus or an indirect method of measurement have proven to be the most popular techniques. In 1942, Leighton devised a instrument using the force of gravity to measure the range of movement of the joint in degrees. The reliability has been shown to be as high as .90 which provides far more accurate results than does the manual goniometer. Some of the researchers using the Leighton flexometer include Leighton (1942), Sigerseth (1950), Hupprich (1950), Massey (1956) and Harris (1969). A similar instrument called the O.B. Myrin goniometer was used by the author for purposes of this study.

Indirect measurement of flexibility involves the rotation of the limb or body part attached to the joint in question in a specific direction. The distance that the body part travels is used to describe the amount of

rotation that occurred within the joint. This type of measurement does not provide a direct reading of joint movement in degrees, rather, it offers comparative measures either for repeated tests of according to norms and sample scores. Indirect measurement was originally designed by Cureton in 1941, after which a number of researchers used his measurement test or at least a similar technique (Wells, 1952; Kraus, 1954; Phillips, 1955; Buxton, 1957; Kusinitz, 1958; Nordschaw, 1961; de Vries, 1962; Fieldman,1966; Cotten,1970; Holt, 1970). Leighton (1954) questioned the use of a linear measurement to measure a rotational motion. He also maintained that the length of the limb will affect the result of the measurement. Subsequent studies have shown that there is very little or no correlation between anthropometric measures and flexibility measures from indirect techniques (Mathews, 1957; Wear, 1963; Harvey, 1967; Harris, 1969; Jensen,1972).

Wells (1952) devised a sit and reach test because she felt that flexibility measures taken from a standing bobbing test (Kraus-Weber floor touch) were limited because of the fear of falling forward. A comparative analysis showed that the sit and reach test was highly reliable as reflected by a score of 0.98 and a validity coefficient of 0.90 when the standing bob test was used as the criterion. Mathews (1957) examined flexibility scores obtained from the adapted Kraus-Weber test, Leighton Flexometer and the Wells Sit and Reach Test. He concluded that the adapted Kraus-Weber Test could be used interchangeably with the Wells Sit and Reach Test. The Leighton Flexometer did not highly correlate with either of the above tests. No indication was given as to which

technique was best.

Strength Training and Flexibility

Many athletes interested in strength training have expressed concern over a loss of flexibility with increased strength gains. Massey and Chaudet (1956) looked at the flexibility component in subjects involved in a weight training program. Results showed that the weight training group decreased in flexibility in five of the seven flexibility measures, four of the five were reported to be significant, while the control group decreased in six of the seven, three of the seven were reported to be significant by the authors. Because of the decrease in both groups, Massey and Chaudet speculated that some systemic influence affected the measurements. A closer look showed that those joints receiving the greatest attention during the weight training program showed a slight increase or at least a lesser decrement. The authors concluded that exercised joints increase in flexibility while unexercised joints became less flexible. Kuzinitz (1958) looked at flexibility measures in conjunction with other fitness components with subjects participating in progressive weight training as compared to a control group. The two flexibility items measured, trunk flexion and extension, increased significantly after a progressive weight training program. Kuzinitz, therefore, concluded that progressive weight training did not restrict specific flexibility measures, and in fact increases were reported. Sigerseth (1950) compared twenty-one flexibility measures on college football players and college service course students. The service course

members were significantly more flexible than football players in thirteen of twenty-one measures while the football players were significantly better in one measure. No causal factors for the differences were discussed.

From a physiological viewpoint, Francis and Tipton (1969) found a five percent decrease patellar reflex with strength increases and by the same token, Reid (1967) found a seven percent decrease in achilles tendon reflex with a twenty-seven percent increase in strength. These studies would suggest that the stretch reflex will allow greater stretch of the muscle, thus flexibility, with strength gains.

Flexibility and Nautilus Weight Training

Despite the fact that the pre - stretch position incorporated in the Nautilus strength training program is highly acclaimed to increase flexibility, a review of the literature has not revealed any studies dealing specifically with flexibility development. Petersen (1975) conducted a study at the United States Military Academy to observe the effects of the Nautilus Training Program on total physical fitness. Included in the battery of tests were four flexibility measures; trunk extension, trunk flexion, shoulder flexion and shoulder extension. Results were expressed as a percentage. Indications were that the experimental group showed greater increases than the control group in three measures; trunk extension (15.58 percent to 1.31 percent), trunk flexion (5.57 percent to 0.26 percent) and shoulder flexion (11.66 percent to 0.99 percent). Results for shoulder extension were not available.

Flexibility gains using Nautilus weight training equipment are said to occur because the exercise is conducted through a full range of motion from full extension to maximum contraction and because of the pre - stretch position. The pre - stretch position is described as the stress placed on the muscle, stretching it to its full length at the beginning of the exercise before muscle contraction occurs. Once the subject is fitted into the equipment and assumes the starting position, the weight stack is no longer in a resting position. The subject's arms or legs are in a position of complete extension and the weight stack is suspended from a network of chains which ultimately connect with the exercise equipment. Consequently, there is a continual force stretching the subject's muscles to the extreme limit that the muscle will allow. The muscle soon adapts to the stress to which it is being subjected and eventually assumes this new length thus increasing the muscle's flexibility component. Jones (1975) states that the resistance must be of substantial weight if an improvement is expected, a light weight will not be effective. As the individual increases in strength and resistance, so does the amount of pre - stretch and flexibility (Jones, 1975).

Darden (1974) sees the pre - stretch position serving a three-fold function: first to stretch the muscles and connective tissue surrounding the joint, thus improving flexibility; then pre - stretching the muscle which triggers the neural impulses to the muscle preparing it for maximal contraction; and thirdly to maximally load the muscle over its entire length beginning at the point of maximal stretch.

CHAPTER III

METHODS AND PROCEDURES

The purpose of the study was to evaluate and compare the flexibility changes of the shoulder using four treatment groups: group one was the static stretching program; group two was the Nautilus training program; group three was the Nautilus program supplemented by the static stretching program and group 4 was a control group.

Apparatus

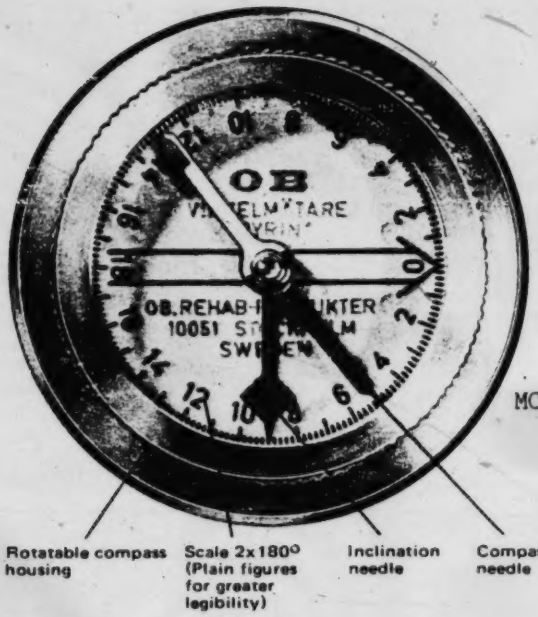
Flexibility measures were obtained using the O.B. Myrin Goniometer. The O.B. Myrin Goniometer was designed in Sweden to measure the range of movement in two planes. The degree of horizontal movement about a joint such as neck rotation or shoulder rotation can be measured using the compass indicator. The instrument is adjusted with the zero mark at the starting position. Any movement in a horizontal plane will be reflected in degrees of motion according to the compass needle. During preliminary tests, the author found that the compass needle recorded inconsistent results for the same movement in different parts of the laboratory. It was speculated that the electrical systems within the laboratory were responsible for the variable measurements. Since the flexibility measures were to be taken at two different locations, the compass readings were discarded as a possible measurement technique.

The instrument also measures joint motion in a vertical plane using an inclination needle. The needle influenced by the force of gravity in a similar fashion as the Leighton Flexometer. As in the previous method the subject assumes a standardized starting position and the inclination needle is matched with the zero point on the dial. As the limb is moved through a range of motion, the inclination needle maintained a perpendicular position to the floor while rotation on the face of the dial. Using this technique, the actual joint motion was recorded in degrees of movement. For purposes of standardization, all of the measures were taken with the instrument attached to the subject's wrist crossing the styloid process.

A check for reliability consisted of twenty measures on two subjects who executed a shoulder flexion through a predetermined 90 degree range. The goniometer was left in position throughout the testing procedure. The results showed a range between 88 and 92 degrees. The standard deviation was 1.4. The instrument as described in a catalogue by Mid-Canada Medical is illustrated in Figure 1.

Nautilus Total Conditioning machines were the only other pieces of equipment used in the study. Nautilus equipment is a recently developed strength training apparatus incorporating an adapted or variable resistance principle with a pre-stretch position. Adapted or variable resistance means that the resistance changes to accommodate for the bio-mechanical variability of the body's lever system. Theoretically then, the muscle is maximally loaded regardless of the changes in the body's lever system. The pre-stretch position stretches the muscle fully, in an effort to maintain or enhance flexibility of the muscle and allow

for maximal resistance over the full length of the muscle.



MCM 12050

Fig. 1 O.B. Myrin Goniometer.*

MCM .12050 - OB "MYRIN" GONIOMETER

Measurements of the range of mobility using previous types of goniometers have been difficult and subject to errors. The newly developed Myrin goniometer makes it possible to measure with considerable accuracy the range of movement in most of the body's joints. The goniometer consists of a fluid-filled container which is rotatably mounted on a plate. The housing contains a compass needle which reacts to the earth's magnetic field and an inclination needle which is influenced by the force of gravity. The compass needle measures movements in the horizontal plane and the inclination needle registers vertical movements. A strap with velcro fastener and, when needed, a straight and an angled plastic strip facilitate the placing of the goniometer on the various joints of the body.

*Supplied by Mid Canada Medical, 1236 Albert Street, Regina, Saskatchewan.

The equipment design is based on a lever system using a rotary cam which varies in shape. The cam is connected to the weight stack by a network of chains. The shape of the cam determines the length of the lever that lifts the weight stack and consequently the resultant resistance to the movement being performed. Each piece of equipment is designed for a specific exercise and makes use of a specifically designed cam.

All of the Nautilus machines aimed at developing the upper body were used during the training program. Each machine concentrated on a different group of muscles surrounding the shoulder joint. A full range of motion was emphasized for each exercise. A total of six machines incorporating twelve exercises were completed by each subject. The machines include (1) Pullover/Torso Arm Machine, (2) Double Chest Machine, (3) Behind Neck Torso Arm Machine, (4) Double Shoulder Machine, (5) Omni Bicep Machine and (6) Omni Tricep Machine. A detailed description of each exercise performed on each machine, as outlined by the Nautilus Manufacturers as well as a list of those muscles involved in each machine can be found in Appendix A.

Subjects

Twenty-eight male volunteers were randomly assigned to four activity groups. Subjects were screened for any previous injury that could influence shoulder flexibility or the ability to correctly perform any of the required exercises. Subjects were also asked to account for their present activity level. Twenty-three subjects reported a medium activity level of three to four hours per week. Seven subjects reported a low

activity level of zero to two hours per week. Subjects involved in flexibility programs were restricted from the study.

Experimental Design

Shoulder flexibility measures were taken prior to and immediately following the four week training period. Each subject was randomly assigned to one of four groups; Static Stretching Exercises (Group 1), Nautilus Training Program (Group 2), Nautilus Training supplemented by Static Stretching Exercises (Group 3), and a control group (Group 4). There were three exercise sessions per week for a total of twelve sessions as prescribed in the Nautilus Training Principles (Appendix A).

Testing Procedure

Five measures of shoulder flexibility were recorded; (1) shoulder flexion, (2) shoulder extension, (3) shoulder abduction, (4) internal rotation and (5) external rotation. Tests were conducted on each individual's dominant side in order to standardize the measures.

Shoulder Flexion

The subject was asked to stand with his back against the wall keeping his shoulder blade over the edge of the corner. Heels, buttocks and shoulders were held tightly against the wall. The goniometer was positioned so that the dial sat on the dorsum of the wrist. With the elbow locked and the fingers extending down the side of the leg, the goniometer was set at the zero position. The subject was then instructed to slowly raise his straight arm forward and along the wall overhead as far as

possible without moving his arm or body away from the wall. A final reading was taken at the extreme range of motion.

Shoulder Extension

The subject assumed the same position as in shoulder flexion. The goniometer should still be at the zero starting position. Keeping in mind not to move the body from the wall, the subject raised his straight arm backwards as far as possible. The final reading was taken in this position.

Shoulder Abduction

Turned to one side with the non-dominant shoulder and arm against the wall, the subject was told to press his dominant hand firmly against his thigh. The goniometer remained on the wrist, but it was positioned so that the dial rested on the ulnar aspect of the wrist facing posteriorly. The needle was aligned with the zero mark and the subject was instructed to raise the arm sideways (abduction) as far as possible without bending the elbow or rotating the shoulder. There should be no bending or twisting of the body. If the subject's head interferred with further movement, he was instructed to bend his head forward. A reading was again taken at the extreme range of motion.

Internal Rotation

The subject was instructed to assume a supine position on the

testing table with the dominant shoulder over the edge. The examiner then positioned the subject's arm in 90 degrees shoulder abduction and 90 degrees elbow flexion with the palm of the hand facing distally. The dial was attached to the wrist as described in the shoulder abduction test. The inclination needle was adjusted to zero. The subject then rotated his arm about an axis travelling through his elbow and upper arm thus dropping his hand forward. The examiner stabilized the upper arm in a horizontal position so that the elbow did not move up or down. The shoulder must also be kept on the table. The reading was taken at the furthest point of motion.

External Rotation

Once the internal rotation score was recorded, the subject resumed the starting position. The inclination needle should still be on the zero mark. The same motion as described in internal rotation was executed in the opposite direction (dropping the hand backwards).

All of the testing was done by one individual the day before the program began and one day following the last training session. Subjects were tested at the same time of day for the pre and post test to eliminate any variation in flexibility measures due to the time of day. To avoid any motivational variables, all flexibility scores were not revealed to subjects until after the final testing was completed.

Training Procedure

Subjects were randomly assigned to one of four groups: group number one was Static Stretching Exercises, group number two was Nautilus Training, group number three was Nautilus Training supplemented by Static Stretching Exercises and group number 4 was a control group. Each subject performed his specific exercises three times per week (Monday, Wednesday, Friday) for four weeks.

Static Stretching Exercises

The static stretching exercises used in the study were of a stretch and hold nature requiring the help of a partner. There were three different exercises and each performed three times for a ten second count (One thousand and one, one thousand and two...one thousand and ten).

Prone Shoulder Flexion. Lying face down with the arms out-stretched overhead, the partner grasped the wrists and slowly raised the subject's arms until he said "hold". The subject's forehead must be held in contact with the floor and the arms must remain straight.

Prone Shoulder Flexion and Abduction. The same position as that described in the prone shoulder flexion exercise is assumed. The partner crossed his arms and grasped the subject's wrists in this criss-cross fashion. The partner then raised the subject's arms to the "hold" position as before, at this point, the partner then slowly crossed the subject's arms (shoulder abduction) until the subject once again said "hold".

Sitting Horizontal Extension. The subject assumed a sitting position

with straight legs. The subject then brought his outstretched arms before him at chest height with his palms together. Both arms were spread to the side and backwards as far as possible maintaining the chest height position. The partner grasped the wrists and slowly retracted the arms backwards until the subject said "hold". The subject must not lean forward and his head must remain erect.

Nautilus Training Program

Subjects in the Nautilus training group made use of the facility and staff of the Nautilus Training Centre in Edmonton, Alberta. During the first session, the Nautilus staff oriented the subject as to the proper form required during the exercises and determined the proper resistance at which to begin the program. The subject then embarked on his exercise program. The Nautilus staff were available for consultation and to ensure proper execution of the exercise. Workouts were conducted at the same time each day three days a week for a four week training period.

Nautilus Supplemented by Static Stretching Program

This group underwent a training routine that combined the Nautilus program and the Static Stretching program as previously described. Both programs were done on the same day and immediately following each other. Nothing was added or deleted from either program.

Control Group

The control group was given no specific instructions as to daily activity. Any subject who was presently involved in or planned to work on a flexibility program was not included in the study.

Data Analysis

The following null hypothesis was formulated:

> Changes in shoulder flexibility as a result of either static stretching exercises, Nautilus training, Nautilus Training supplemented by static stretching exercises and a control group do not show a statistically significant difference.

To minimize any inaccuracies due to a learning effect of motivational factors, two measures of each test were taken for each flexibility measure and the mean score was calculated. This mean score was calculated and used as the value. The true scores from the pre and post tests were then compared to determine the flexibility change as a result of the training program. The flexibility change for each individual was then summed to give a mean flexibility change for that treatment group. The mean flexibility change was subjected to subsequent data analysis.

The analysis of the data made use of a one-way analysis of variance (Weber, 1970). A .05 level of significance was used to determine statistically significant differences. F-ratios that were found to be significant at the .05 level of confidence were subjected to the Newman-Keuls Multiple Comparison Test (Winer, 1962).

CHAPTER IV

RESULTS

The purpose of the study was to compare the effects of four treatment groups: static stretching exercise (group 1); Nautilus training (group 2); Nautilus training supplemented by static stretching (group 3); and a control (group 4), on five dependent variables of shoulder flexibility. The five dependent variables of shoulder flexibility are: flexion, extension, abduction, internal rotation and external rotation.

Data was collected for the five dependent variables for each treatment condition prior to and immediately following the four week training program. One-way analysis of variance was employed to determine any statistically significant differences in flexibility gains for each dependent variable. Any statistically significant differences were subsequently subjected to a Newman-Keuls Multiple Comparison Test to isolate the treatment groups responsible for these differences.

For purposes of simplicity, all tables will refer to the treatment groups by their designated number; (1) static stretching exercises, (2) Nautilus training program, (3) Nautilus training supplemented by static stretching exercises and (4) the control group. Changes in flexibility maybe expressed as fractions of degrees in the data analysis despite the fact that our measurements were made to the nearest degree.

Shoulder Flexion

The mean scores and standard deviations for the pre and post test measures of each treatment group are listed in Table I. The mean flexibility change attributed to each group ranges from a 16 degree increase with the Nautilus program supplemented with a stretching program (Group 3) to a .86 degree decrease in flexibility in the case of the control group (Group 4). Analysis of variance of the mean flexibility change (Table II) produced an F-ratio of 13.1, which was found to be significant at the .05 level of confidence. The Newman-Keuls Multiple Comparison Test was subsequently used to identify the specific treatment groups responsible for the significant changes (Table III). The test revealed that the flexibility changes using the Nautilus weight training (Group 2) and Nautilus weight training supplemented with stretching exercises (Group 3) showed statistically significant increases as compared to the control group (Group 4). The increase in shoulder flexion between Group 2 and 3 were not significantly different from each other, but Group 2 and 3 were significantly different from the static stretching group (Group 1).

Shoulder Extension

None of the treatment groups resulted in statistically significant changes in shoulder extension. An analysis of variance produced an F-ratio of 0.45, which was non-significant at the .05 level of confidence (Table V).

Table I

Mean Shoulder Flexion, Pre and Post Test,
for Each Treatment Group

TREATMENT GROUP	1		2		3		4	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
MEAN (DEG)	198.1	202.4	190.1	201.3	195.9	211.9	195.9	195.1
STANDARD DEVIATION	8.1	9.2	17.2	11.4	10.7	11.4	10.2	10.5
MEAN FLEXIBILITY CHANGE (DEG)	4.4		11.2		16.0		-.86	

Table II

Analysis of Variance for Shoulder Flexion
Following the Treatment Program

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO
BETWEEN	1326.9	3	442.3	13.1*
WITHIN	814.7	24	33.9	
TOTAL	2141.6	27		

Critical F Ratio 3.01

* Significant at 5 Level

Table III

Newman - Keuls Multiple Comparison Test for Shoulder Flexion Following the Treatment Program

TREATMENT (DEG)	4 -.86	1 4.4	2 13.9	3 16.
4 -.86		2.39	6.72*	7.66*
1 4.4			6.71*	5.27*
2 13.9				.95
3 16.				
Q_{95} (R,24)		2.92	3.53	3.90

* Significant at the 0.5 Level

Table IV

Mean Shoulder Extension, Pre and Post Test, for Each Treatment Group

TREATMENT GROUP	1		2		3		4	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
MEAN (DEG)	61.7	67.0	59.6	57.4	62.7	67.6	60.9	63.4
STANDARD DEVIATION	13.7	16.4	18.5	22.2	23.1	14.6	19.9	17.9
MEAN FLEXIBILITY CHANGE	5.3		-2.2		4.9		2.4	

Table V

Analysis of Variance for Shoulder
Extension Following the Treatment Program

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO
BETWEEN	250.9	3	83.6	0.45*
WITHIN	4461.9	24	185.9	
TOTAL	4712.8	27		

Critical F Ratio 3.01

* Non-significant at .05 Level

Shoulder Abduction

Mean scores for shoulder abduction are listed in Table VI. The mean flexibility change ranged from 7 to 18.5 degrees. An analysis of variance produced an F-ratio of 3.2 which was significant at the .05 level of confidence (Table VII). A Newman-Keuls Multiple Comparison Test revealed that only the Nautilus supplemented with a stretching program (Group 3) provided significant flexibility increases as compared to the control group (Table VIII). There was no significant difference between treatment groups.

Internal Rotation

Mean flexibility changes shown in Table IX depict flexibility increases resulting from the three treatment groups and a decrease in internal rotation in the control group. An analysis of variance

revealed an F-ratio of 7.2 (Table X), which proved to be significant at the .05 level of confidence. This proved to be significant at the .05 level of confidence. Results from the Newman-Keuls Multiple Comparison Test revealed that flexibility gains were statistically significant as a result of the static stretching (Group 1), Nautilus training (Group 2), and the Nautilus plus static stretching (Group 3) as compared to the control group (Group 4). The three treatment groups did not significantly differ from each other.

Table VI

Mean Shoulder Abduction, Pre and Post Trest, for Each Treatment Group

TREATMENT GROUP	1		2		3		4	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
MEAN (DEG)	190.3	197.4	186.4	198.3	189.5	208.0	185.9	189.8
STANDARD DEVIATION	14.1	9.1	23.5	19.2	8.0	11.5	18.5	18.3
MEAN FLEXIBILITY CHANGE (DEG)	7		11.8		18.5		3.9	

Table VII

Analysis of Variance for Shoulder Abduction Following the Treatment Program

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO
BETWEEN	852.6	3	284.2	3.2*
WITHIN	2154.0	24	89.8	
TOTAL	3006.6	27		

Critical F Ratio 3.01

* Significant at the .05 Level

Table VIII

Newman - Keuls Multiple Comparison Test for Shoulder Abduction Following the Treatment Program

TREATMENT (DEG)		4 3.9	1 7.	2 11.8	3 18.5
4	3.9		.86	2.21	4.08*
1	7.			1.34	3.21
2	11.8				1.87
3	18.5				
Q_{95} (R,24)			2.92	3.53	3.90

* Significant at the .05 Level

Table IX

Mean Internal Rotation, Pre and Post Test,
for Each Treatment Group

TREATMENT GROUP	1		2		3		4	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
MEAN (DEG)	64.6	74.4	65.4	78.7	67.4	86.8	73.6	69.8
STANDARD DEVIATION	12.7	13.2	12.1	11.4	8.2	10.2	7.3	9.0
MEAN FLEXIBILITY CHANGE (DEG)	9.7		14.4		20.4		-2.9	

Table X

Analysis of Variance for Internal
Rotation Following the Treatment Program

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F-RATIO
BETWEEN	2050.5	3	683.5	7.2*
WITHIN	2264.5	24	94.4	
TOTAL	4315.0	27		

Critial F Ratio 3.01

*Significant at the .05 Level

Table XI

Newman - Keuls Multiple Comparison Test for Internal Rotation Following the Treatment Program

TREATMENT (DEG)	4 -2.9	1 9.7	2 14.4	3 20.4
4		3.43*	4.71*	6.35*
1			1.28	2.91
2				1.63
3				
Q_{95} (R,24)		2.92	3.53	3.90

* Significant at the .05 Level

External Rotation

External rotation of the shoulder also showed statistically significant improvements in flexibility. The mean scores (Table XII) showed an increase in flexibility as a result of all four groups. Mean flexibility changes ranged from an increase of 1.9 to 17.5 degrees. The standard deviation for each measure ranged from 8.5 to 18.9 degrees. The analysis of variance in Table XIII produced an F-ratio of 3 03, which was statistically significant at the .05 level of confidence.

The Newman-Keuls Multiple Comparison Test revealed that two training programs showed a statistically significant increase in external rotation of the shoulder as compared to the control group (Table XIV).

The programs were the static stretching program (Group 1) and the Nautilus and supplementary stretching program (Group 3). None of the three treatment groups significantly differed from each other.

Table XII

Mean External Rotation, Pre and Post Test, for Each Treatment Group

TREATMENT GROUP	1		2		3		4	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
MEAN (DEG)	97.7	114.4	97.4	114.8	100.9	117.5	102.1	104.2
STANDARD DEVIATION	18.9	12.1	17.5	16.0	12.4	8.5	18.3	10.4
MEAN FLEXIBILITY CHANGE (DEG)	16.7		17.5		16.5		1.9	

Table XIII

Analysis of Variance for External Rotation Following the Treatment Program

SOURCE	SUM OF SQUARES	DF	MEAN SQUARES	F-RATIO
BETWEEN	1136.2	3	378.7	3.03*
WITHIN	2997.6	24	124.9	
TOTAL	4133.8	27		

Critical F Ratio 3.01

* Significant at the .05 Level

Table XIV

Newman - Keuls Multiple Comparison Test
For External Rotation Following the Treatment
Program

TREATMENT (DEG)	4	3	1	2
4		3.14*	3.53*	3.71
3			.38	.57
1				.19
2				
Q_{95} (R,24)		2.92	3.53	3.90

* Significant at the .05 Level

CHAPTER V

DISCUSSION

The purpose of the study was to evaluate and compare the shoulder flexibility changes occurring as a result of four treatment groups: static stretching exercises (Group 1); Nautilus weight training (Group 2); Nautilus weight training supplemented by static stretching exercises (Group 3) and a control group (Group 4).

Shoulder Flexion

The Nautilus group (Group 2) and the Nautilus supplemented by stretching group (Group 3) showed statistically significant changes as compared to the control group (Group 4). The Nautilus group and Nautilus plus stretching group were also significantly different from the static stretching group (Group 1) but there was no significant difference between each other. The results indicate that supplementary static stretching exercises are not essential to the improvement in shoulder flexion when using Nautilus weight training equipment. From the data presented in Table I, it is evident that the Nautilus pullover machine contributes the greatest influence on shoulder flexion because of its closely related movement and continual stretch on the involved muscles at the starting point of the exercise. This pre-stretch position would seem to be more effective than the stress provided by the prone shoulder

flexion exercise used by the static stretching group.

Shoulder Extension

There were no significant differences in shoulder extension measures for any treatment groups when compared to the control group. Static stretching exercises aimed at developing shoulder extension were purposely avoided because there did not seem to be a Nautilus machine that duplicated the shoulder extension exercise. The results would indicate that if the development of shoulder extension is desired, some form of supplementary program should accompany the Nautilus weight training program.

Shoulder Abduction

Only the Nautilus supplemented by stretching group (Group 3) showed any statistically significant increase in shoulder abduction as compared to the control group. None of the treatment groups significantly differed from the other. The Behind Neck Torso Machine was the only Nautilus machine that placed any stress on shoulder abduction. It would seem from the data that significant improvements in shoulder abduction as a result of the Nautilus program requires supplementary stretching exercises. Nautilus training and static stretching exercises on their own, do not result in a significant increase in shoulder abduction.

Internal Rotation

The three treatment groups showed a statistically significant increase in internal rotation as compared to the control group (Table XI). The control showed a negative mean flexibility change of 2.9 degrees. The treatment groups did not significantly differ from the others. This could be explained by the fact that none of the treatment exercises were specifically aimed at internal rotation as such, although many of the exercises involved those muscles that are stretched during internal rotation, namely the rotator cuff muscles.

External Rotation

The data describing the changes in external rotation of the shoulder (Table XIV) showed that statistically significant increases ocurred as a result of the static stretching program (Group 1) and from the Nautilus training program supplemented by static stretching exercises (Group 3). Changes from the Nautilus training group (Group 2) were not statistically significant. It is hypothesized that static stretching exercises were the determining factor in providing statistically significant increases in external rotation of the shoulder. As was discussed with respect to internal rotation, no exercises specifically aimed at developing external rotation were part of the treatment procedures.

General Discussion

Table XV outlines the three treatment groups and those flexibility measures for which a statistically significant increase was reported. From Table XV it is apparent that the greatest increase in flexibility occurred using the Nautilus supplemented by static stretching exercises. The Nautilus program showed significant improvements in shoulder flexion and internal rotation while static stretching exercises showed statistically significant increases in internal and external rotation. The Nautilus supplemented by static stretching group was responsible for statistically significant increases in four of the five flexibility measures. In each case, two of the five flexibility measures were statistically significant for the static stretching group and the Nautilus training group.

Table XV

Statistically Significant Flexibility Changes Attributed to Each Treatment Group as Compared to the Control Group

STATIC STRETCHING	NAUTILUS	NAUTILUS SUPPLEMENTED BY STATIC STRETCHING
SHOULDER FLEXION	*SHOULDER FLEXION	*SHOULDER FLEXION
SHOULDER EXTENSION	SHOULDER EXTENSION	SHOULDER EXTENSION
SHOULDER ABDUCTION	SHOULDER ABDUCTION	*SHOULDER ABDUCTION
*INTERNAL ROTATION	*INTERNAL ROTATION	*INTERNAL ROTATION
*EXTERNAL ROTATION	EXTERNAL ROTATION	*EXTERNAL ROTATION

* Significant increases in flexibility at the .05 Level of Confidence.

Most research tries to control or eliminate outside variables that may influence the results. Although the subjects in the study were randomly assigned, the motivational factor was difficult to control with specific groups. Because Nautilus was a new training system, subjects were very interested in the program. For this reason, the motivational factor may not have been controlled as desired. It is possible that these people were more willing to make a greater effort because the machines were a novelty. From a practioner's viewpoint, the factor of motivation cannot be construed as a negative influence. If the

objective of the program is to increase flexibility and the apparatus has motivated the subjects to fulfill this objective, then the Nautilus equipment has served its functions.

The question of differences in the potential for flexibility increases is a difficult one to resolve. One subject may have greater flexibility increases than another, despite the same amount of exercise, simply because of innate anatomical characteristics. The assumption is that random sampling will resolve the problem, providing that the sample is of sufficient size.

It is generally accepted that some people are more flexible than others, but there does not seem to be any method of distinction. It is also generally accepted that too little flexibility leads to injury through muscle pulls and that too much flexibility could lead to possible dislocations and other joint related injuries. A concrete definition for too much or too little flexibility has so far eluded us, and any attempt at identifying ideal flexibility is merely guesswork.

As previously mentioned, the answers are yet to be found, and they are a necessity if we are to provide our athletes with conditioning programs which will protect the individual from injury and enhance performance. Epidemiological studies of the incidence and severity of injuries on athletes who have been pre-examined for specific flexibility measures could help to provide some of the answers.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to compare the shoulder flexibility changes that occurred as a result of a Static Stretching program, a Nautilus Training program and a Nautilus training program supplemented by a static stretching program.

The testing procedure consisted of a pre and post test design. Five measures of shoulder flexibility were recorded including shoulder flexion, shoulder extension, shoulder abduction, internal and external rotation. The O.B. Myrin Goniometer was used to obtain the flexibility measures.

Twenty-eight males volunteered to act as subjects. Each subject was randomly assigned to one of four treatment groups; (1) Static Stretching exercises, (2) Nautilus training program, (3) Nautilus training program plus Static Stretching exercises and (4) a control group. Flexibility measures were taken prior to and immediately following a four week training program which consisted of three sessions per week.

The data was analyzed by means of a one-way analysis of variance. Significant measurements at the .05 level of confidence were subjected to the Newman-Keuls multiple comparison test.

Conclusion

Within the restrictions of the study, the null hypothesis was rejected at the .05 level of confidence for shoulder flexion, shoulder abduction, shoulder internal rotation and shoulder external rotation. The data from the study allowed for the following conclusions:

1. Supplementary static stretching exercises are not essential for the improvement in shoulder flexion when using the Nautilus weight machines.

2. None of the treatment groups significantly changed flexibility measures for shoulder extension.

3. Only the Nautilus supplemented by static stretching group showed any statistically significant increases in shoulder abduction. Because Nautilus alone and static stretching alone did not significantly increase shoulder abduction, a combination of the two is required.

4. All three treatment groups showed a statistically significant increase in shoulder internal rotation. None significantly differed from the other.

5. If external rotation of the shoulder is to be improved, it would seem that supplementary static stretching exercises are required when using Nautilus weight machines.

6. From the data, it is apparent that the most consistent improvements in shoulder flexibility were a result of the Nautilus program supplemented by static stretching exercises.

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APPENDIX A.

APPARATUS

NAUTILUS TRAINING MACHINES

Nautilus Training Principles

General procedures to be followed on all machines where the regular (positive - negative) form of exercise is performed:

1. On any machine where seat adjustments or body positioning can be varied, make certain that the rotational axis of the cam is directly parallel to the rotational axis (joint) of the body part that is being moved.

2. Position your body in a straightly aligned manner. Avoid twisting or shifting your weight during the movement.

3. Never squeeze hand grips tightly, but maintain a loose, comfortable grip (a tight grip elevates blood pressure).

4. Lift the resistance (positive work) to the count of two... pause...lower the resistance (negative work) slowly and smoothly while counting to four.

5. For full-range strength and flexibility (and protection against injury) your range of movement on each machine should be as great as possible.

6. Breathe normally. Try not to hold your breath while straining.

7. Perform each exercise for 8 to 12 repetitions.

    a. Begin with a weight you can comfortably do 8 times.

    b. Stay with that weight until you can perform 12 strict repetitions. On the following workout, increase the weight (approximately 5%) and go back to 8 repetitions.

    c. Ideally, on every workout you should progress in repetitions and/or resistance.

8. For best cardiorespiratory (heart - lungs) conditioning, move quickly from machine to machine (this speed does not apply to the actual exercises). The longer the rest between machines, the less effective the cardiorespiratory conditioning.

9. When possible, follow your routine as the exercises are numbered on your workout sheet; however, any time the machine you are to do next is being used, go to another exercise and then return to the machine that was in use.

10. All compound and double machines were designed to make use of the pre - exhaustion principle (where a single - joint exercise is used to pre - exhaust a given muscle and a multiple - joint exercise is used to force the exhausted muscle to work even harder); therefore, it is important to move very quickly (in less than 3 seconds) from the primary exercise to the secondary exercise.

11. Your training session should include a maximum of 12 exercises, 4 to 6 for the lower body and 6 to 8 for the upper body (a compound machine counts as two exercises).

12. Exercise the larger muscle groups first and proceed down to the smaller muscle groups (hips, thighs, back, shoulders, chest, arms, and neck).

13. Your entire workout should take from 20 to 30 minutes.

14. The time lapse between exercise sessions should be at least 48 hours and not more than 96 hours.

Pullover/Torso Arm Machine

Pullover (Latissimus dorsi muscles of the back and other torso muscles)

1. Adjust seat so shoulder joints are in line with axes of cams.

2. Assume erect position and fasten seat belt tightly.

3. Leg press foot pedal until elbow pads are about chin level.

4. Place elbows on pads.

5. Hands should be open and resting on curved portion of bar.

6. Remove legs from pedal and slowly rotate elbows as far back as possible.

7. Stretch.

8. Rotate elbows down until bar touches stomach.

9. Pause.

10. Slowly return to stretched position and repeat.

11. After final repetition, immediately do pulldown.

Important: Look straight ahead during movement. Do not move head or torso. Do not grip tightly with hands.

Torso Arm Pulldown (latissimus dorsi of back and biceps of upper arms)

1. Lower seat to bottom for maximum stretch.
2. Grasp overhead bar with palms-up grip.
3. Keep head and shoulders against seat back.
4. Pull bar to chest.
5. Pause.
6. Slowly return to stretched position and repeat.

Double Chest Machine

Arm Cross (pectoralis majcrs of the chest and deltoids of shoulders)

1. Adjust seat until shoulders (when elbows are together) are directly under axes of overhead cams.
2. Fasten seat belt.
3. Place forearms behind and firmly against movement arm pads.
4. lightly grasp handles (thumb should be around handle) and keep head against seat back.
5. Push with forearms and try to touch elbows together in front of chest. (Movement can also be done one arm at a time in an alternate fashion.)
6. Pause.
7. Slowly lower resistance and repeat.
8. After final repetition, immediately do decline press.

Decline Press (Chest, shoulders, and triceps of arms)

1. Use foot pedal to raise handles into starting position.
2. Grasp handles with parallel grip.
3. Keep head back and torso erect.
4. Press bars forward in controlled fashion.
5. Slowly lower resistance keeping elbows wide.
6. Stretch at point of full extension and repeat pressing movement.

Behind Neck/Torso Arm Machine

Behind Neck (Latissimus dorsi of back)

1. Adjust seat so shoulder joints are in line with axes of cams.
2. Fasten seat belt.
3. Place back of upper arms (triceps area) between padded movement arms.
4. Cross forearms behind neck.
5. Move both arms downward until perpendicular to floor.
6. Pause.
7. Slowly return to crossed - arm position behind neck and repeat.
8. After final repetition, immediately do behind neck pulldown.

Important: Be careful not to bring arms or hands to front of body.

Behind Neck Pulldown (Latissimus dorsi of back and biceps of upper arms)

1. Lean forward and grasp overhead bar with parallel grip.
2. Keeping elbows back, pull bar behind neck.
3. Pause.
4. Slowly return to starting position and repeat.

Double Shoulder Machine

Lateral Raise (Deltoid muscles of shoulders)

1. Adjust seat so shoulder joints are in line with axes of cams.
2. Fasten seat belt.
3. Pull handles back until knuckles touch pads.
4. Lead with elbows and raise both arms until parallel with floor.
5. Pause.
6. Slowly lower resistance and repeat.
7. After final repetition, immediately do overhead press.

Important: Keep knuckles against pads and elbows high at all times.

Overhead Press (Deltoids and triceps)

1. Grasp handles above shoulders.
2. Press handles overhead.
3. Slowly lower resistance keeping elbows wide and repeat.

Important: Do not arch back. Legs should be resting on seat throughout both exercises.

Omni Tricep Machine

(Triceps of upper arms)

1. Adjust seat bottom so shoulders are slightly below elbows.
2. Adjust seat back so elbows are in line with axis of cam.
3. Pads of movement arm should be on wrists.
4. Keep thumbs up and head back.
5. Straighten arms smoothly.
6. Pause.
7. Slowly lower resistance and repeat.

Important: Exercise may be performed in negative - only fashion by lifting resistance with legs and lowering with arms. Exercise may be performed in negative - accentuated fashion by lifting resistance with both arms and lowering with only one arm.

Omni Bicep Machine

(Biceps of upper arms)

1. Place elbows on pad and in line with axis of cam.
2. Adjust seat so shoulders are slightly below elbows.
3. Wrists should be under pads and palms open.
4. Twist (supinate) hands as resistance is curled.
5. Keep torso and head back.
6. Pause in contracted position.
7. Slowly lower resistance and repeat.

Important: Exercise may be performed in negative - only fashion by lifting resistance with legs and lowering with arms. Exercise may be performed in negative - accentuated fashion by lifting resistance with both arms and lowering with only one arm.

APPENDIX B.

DATA

FLEXIBILITY INCREASES: NAUTILUS

VS

STATIC STRETCHING EXERCISES

DATA SHEET

NAME _____

ADDRESS _____

PHONE _____

AGE _____(YRS.)_____(MOS.)_____

HAND DOMINANCE: R._____ L._____

PRESENT ACTIVITY LEVEL: HIGH_____MEDIUM_____LOW_____

PREVIOUS INJURY TO THE SHOULDER, ELBOW, HIP, KNEE, BACK.
IF YES, EXPLAIN WHAT AND WHEN_____

_____

SURGERY? YES_____NO_____

FOR OFFICE USE ONLY

GROUP 1 2 3 4

SHOULDER FLEXIBILITY

		PRE-TEST	POST-TEST
FLEXION AND EXTENSION	(1)		
	(2)		
	(x)		
ABDUCTION	(1)		
	(2)		
	(x)		
ROTATION	(1)		
	(2)		
	(x)		

SHOULDER FLEXION

Group A - Stretch
Group B - Nautilus
Group C - Nautilus & Stretch
Group D - Control

Group A			Group B			Group C			Group D		
PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF
208	210	+2	190.5	204	+13.5	208	227	+19	192.5	194	+1.5
191	194	+3	196	205.5	+11.5	198	199	+1	177	176.5	-.5
202	205.5	+3.5	200.5	205.5	+5	212	224	+12	203	204.5	+2.5
202	215	+13	190	214.5	+24.5	183.5	200	+16.5	196	193.5	-2.5
197.5	202.5	+5	216	208.5	+8.5	187	203	+16	195	198	+3
184	188	+4	169	188	+19	191.5	214.5	+23	198	190	-8
202	202	0	168	183	+15	191	215.5	+24.5	210	208	-2
x 198.1	x 202.4		x 190.1	x 201.3		x 195.9	x 211.9		x 195.9	x 195.1	
S.D 8.1	S.D 9.2		S.D. 17.2	S.D. 11.4		S.D. 10.7	S.D. 11.4		S.D. 10.2	S.D. 10.5	

SHOULDER EXTENSION

Group A - Stretch
Group B - Nautilus

Group C - Nautilus & Stretch
Group D - Control

Group A			Group B			Group C			Group D		
PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF
57	56	-1	84.5	52.5	-32	66	52	-14	42.5	44.5	+2
39	48	19	57	57	0	39	53	+14	46	46	0
51	62.5	+11.5	70	60	-10	65.5	65.5	0	67.5	70.5	+3
71	83	+12	44.5	34.5	-10	38	72	+34	64.5	77	+12.5
80	93	+13	77.5	104	+26.5	55	68	+13	95	87.5	-7.5
66	54.5	-11.5	33.5	47.5	+14	69	67	-2	72	73.5	+1.5
68	72	+4	50	46	-4	106.5	96	-10.5	39	44.5	+5.5
x 61.7	x 67.0		x 59.6	x 57.4		x 62.7	x 67.6		x 60.9	x 63.4	
S.D. 13.7	S.D. 16.4		S.D. 18.5	S.D. 22.2		S.D. 23.1	S.D. 14.6		S.D. 19.9	S.D. 17.9	

SHOULDER ABDUCTION

Group A - Stretch
Group B - Nautilus
Group C - Nautilus & Stretch
Group D - Control

Group A			Group B			Group C			Group D		
PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF
203.5	209.5	+6	196.5	200	+3.5	197	219	+22	215.5	213	-2.5
190	199.5	+9.5	173	183.5	+9.5	197	207	+10	169.5	165	-4.5
195	199.5	+4.5	192.5	205.5	+13	194	226	+32	171.5	191	+19.5
169.5	181.5	+12	195.5	208.5	+13	182	198	+16	194	203	+9
210	204	-6	226	229	+3	188	209	+21	182	196.5	+14.5
178	191	+13	161	192.5	+31.5	192.5	193	+.5	167	165	-2
186	196.5	+10.5	160	169	+9	176	204	+28	202	195	-7
x 190.3	x 197.4		x 186.4	x 198.3		x 189.5	x 208		x 185.9	x 189.8	
S.D. 14.1	S.D. 9.1		S.D. 23.5	S.D. 19.2		S.D. 8.0	S.D. 11.5		S.D. 18.5	S.D. 18.3	

SHOULDER INTERNAL ROTATION

Group A – Stretch
Group B – Nautilus
Group C – Nautilus & Stretch
Group D – Control

Group A			Group B			Group C			Group D		
PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF
88	92	+4	79	65	-14	59	81	+29	75	70	-5
57	60.5	+3.5	72	93	+21	62	77	+15	70	67	-3
52	59.5	+7.5	53.5	80	+26.5	65	87	+22	78.5	88	+9.5
72	88	+16	64	71	+7	68	74.5	+6.5	85	68	-17
64	72.5	+8.5	74	95	+21	68.5	93.5	+25	70	72	+2
67	82	+15	45	74	+29	65	91	+2.6	62	60	-2
52.5	66	+13.5	70	73	+3	84.5	103.5	+19	74.5	63.5	-11
x 64.6	x 74.4		x 65.4	x 78.7		x 67.4	x 86.8		x 73.6	x 69.8	
S.D. 12.7	S.D. 13.2		S.D. 12.1	S.D. 11.4		S.D. 8.2	S.D. 10.2		S.D. 7.3	S.D. 9.0	

SHOULDER EXTERNAL ROTATION

Group A - Stretch
Group B - Nautilus
Group C - Nautilus & Stretch
Group D - Control

Group A			Group B			Group C			Group D		
PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF	PRE	POST	DIFF
70	101	+31	103.5	108.5	+5	86	112.5	+25.5	67	90.5	+13.5
80	105	+25	108	127.5	+19.5	119	110	-19	109	117	+8
111	134.5	+23.5	97	122	+25	107	123	+16	102	103.5	+1.5
113	119.5	+6.5	91	116.5	+25.5	92	108	+16	119	116	-3
212	214.5	+3.5	126.5	138	+11.5	90	123	+33	97	108.5	+11.5
101	107.5	+6.5	81	97	+16	112.5	131.5	+19	122	101	-21
88	109	+21	74.5	94	+19.5	100	114.5	+14.5	98.5	93	+2.5
x 97.7	x 114.4		x 97.4	x 114.8		x 100.9	x 117.5		x 102.1	x 104.2	
S.D. 18.9	S.D. 12.1		S.D. 17.5	S.D. 16.0		S.D. 12.4	S.D. 8.5		S.D. 18.3	S.D. 10.4	

FLEXIBILITY CHANGES FOR SHOULDER FLEXION

	TREATMENTS				
	Group 1	Group 2	Group 3	Group 4	
	2.0	13.5	19.0	1.5	
	3.0	11.5	1.0	-0.5	
	3.5	5.0	12.0	2.5	
	13.0	24.5	16.5	-2.5	
	5.0	8.5	16.0	3.0	
	4.0	19.0	23.0	-8.0	
	0.0	15.0	24.5	-2.0	TOTAL
N	7	7	7	7	28
T	30.5	97.0	112.0	-6	233.5
$\bar{x}$	4.4	13.9	16.0	-0.86	
Σx^2	235.3	159.8	2163.5	92.0	4088.8
$\frac{T^2}{N}$	132.9	1344.1	1792.0	5.1	3274.1

FLEXIBILITY CHANGES FOR SHOULDER EXTENSION

	TREATMENTS				
	Group 1	Group 2	Group 3	Group 4	
	-1.0	-32.0	-14.0	2.0	
	9.0	0.0	14.0	0.0	
	11.5	-10.0	0.0	3.0	
	12.0	-10.0	34.0	12.5	
	13.0	26.5	13.0	-7.5	
	-11.5	14.0	-2.0	1.5	
	4.0	-4.0	-10.5	5.5	TOTAL
N	7	7	7	7	28
T	37	-15.5	34.5	17.	73
x	5.3	-2.2	4.9	2.4	
Σx^2	675.5	2138.3	1831.3	248.	4903.1
$\frac{T^2}{N}$	195.6	34.3	170.0	41.3	441.2

FLEXIBILITY CHANGES FOR SHOULDER ABDUCTION

	TREATMENTS				
	Group 1	Group 2	Group 3	Group 4	
	6.0	3.5	22.0	-2.5	
	9.5	9.5	10.0	-4.5	
	4.5	13.0	32.0	19.5	
	12.0	13.0	16.0	9.0	
	-6.0	3.0	21.0	14.5	
	13.0	31.5	0.5	-2.0	
	10.5	9.0	28.0	-7.0	TOTAL
N	7	7	7	7	28
T	49	82.5	129.5	27	288
x	7	11.8	18.5	3.9	
Σx^2	605.8	1522.8	3089.3	751.0	5968.9
$\frac{T^2}{N}$	343.0	972.3	2395.8	104.1	3814.9

FLEXIBILITY CHANGES FOR INTERNAL ROTATION
OF THE SHOULDER

	TREATMENTS				
	Group 1	Group 2	Group 3	Group 4	
	4.0	-14.0	29.0	5.0	
	3.5	21.0	15.0	-7.0	
	7.5	26.5	22.0	9.5	
	16.0	7.0	6.5	-17.0	
	8.5	21.0	25.0	2.0	
	15.0	29.0	26.0	-2.0	
	13.5	3.0	19.0	-11.0	TOTAL
N	7	7	7	7	28
T	68	100.5	142.5	-20.5	290.5
x	9.7	14.4	20.4	-2.9	3013.9
Σx^2	820	2679.3	3254.3	582.3	7328.9
$\frac{T^2}{N}$	660.6	1442.9	2900.9	60.0	5064.4

FLEXIBILITY CHANGES FOR EXTERNAL ROTATION
OF THE SHOULDER

	TREATMENTS				
	Group 1	Group 2	Group 3	Group 4	
	31.0	5.0	25.5	13.5	
	25.0	19.5	-9.0	8.0	
	23.5	25.0	16.0	1.5	
	6.5	25.5	16.0	-3.0	
	3.5	11.5	33.0	11.5	
	6.5	16.5	19.5	-21.0	
	21.0	19.5	4.5	2.5	TOTAL
N	7	7	7	7	28
T	117	122.5	105.5	13	
x	16.7	17.5	15.1	1.9	358
Σx^2	2676	2465.3	2732.8	837	8711.1
$\frac{T^2}{N}$	1955.6	2143.8	1590.0	24.1	5713.5

APPENDIX C.

SUBJECT INSTRUCTIONS

STRETCHING EXERCISES

NOTE: ALL EXERCISES ARE DONE SLOWLY AND HELD AT THE POINT WHERE THE MUSCLE IS STRETCHED AS MUCH AS POSSIBLE FOR THE COUNT OF 1001, 1002, 1003,... 1010. EACH EXERCISE IS REPEATED THREE (3) TIMES.

1. Prone Shoulder Flexion

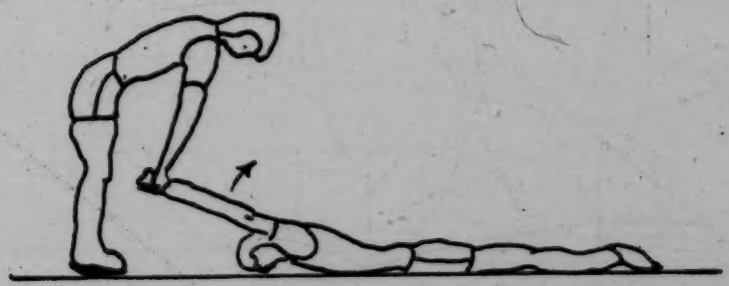
   a) lying face down

   b) arms stretched overhead

   c) partner grasps wrists and slowly pulls upward until subject says "hold"

   d) forehead must be held in contact with the floor

   e) hold for 10 seconds



2. Prone Shoulder Flexion and Abduction

   a) assume same position as number 1.

   b) raise arms to "hold" position and then cross arms until subject says "hold"

   c) hold for 10 seconds

3. Sitting Horizontal Extension

a) sitting legs straight

b) bring arms straight out in front with palms together

c) bring back your arms as far as possible

d) partner then slowly pulls back until subject says "hold" - hold for 10 seconds

e) DO NOT LEAN FORWARD

NOTE: These exercises should be done three (3) time per week (M. W. F.) on a regular basis.

Thank you

Glen Bergeron

For further Information Phone: 436-3338.

NAUTILUS TRAINING PROGRAM

The experienced staff of the Nautilus Training Centre has graciously offered to consult with subjects regarding the use and progression of the involved machines, please follow their instructions diligently.

Because subjects are guests of the Nautilus people, please remember that members must receive priority for the use of the equipment and ONLY THE INVOLVED EQUIPMENT CAN BE USED. Please be patient and understanding. Your cooperation in this project is very much appreciated.

Thank you,

Glen Bergeron.

For further information phone: 435-3338.